STAGGER-TUNED CONSTANT ENVELOPE-DELAY VIDEO I.F. AMPLIFIERS

BY

ARTHUR WU-NIEN LO

B.S., Yenching University, 1938
M.A., Oberlin College, 1946

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENGINEERING
IN THE GRADUATE COLLEGE OF THE
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Introduction

By far the greater part of the amplification of picture signals in a superhetrodyne television receiver takes place in the video I.F. amplifier, which is also the chief source of distortion. As the phase distortion is of prime importance in the transmission of video signals, the fidelity of a video I.F. amplifier depends on the phase characteristic as well as the amplitude characteristic of the amplifier. For minimum phase-shift networks like the passive ladder networks, the two response characteristics are the consequence of each other; one completely specifies the other.

As the video amplifier is fundamentally an amplifier of transient voltages, it is suggested (1) that the response to a Heaviside unit voltage is the most logical and relevent criterion of the fidelity of the amplifier. Conventional designs (2,3) emphasize the constant amplitude condition, which results in an envelope-delay characteristic with large variations over the pass-band, especially near cut-off. This type of amplifier gives a unit voltage response with large overshoot, which is not desirable in a television system.

In order to get a symmetrical unit voltage response without overshoot it is suggested (4) that the best steady-state response characteristics of a video amplifier of a prescribed band-width and gain is such that the envelope-delay characterisitc is constant over the pass-band. This condition specifies a dropping amplitude characteristic approximating a Gaussian error curve. The object of the present work is to design and investigate the performance of this type of amplifier.

The Design Of The Stagger-tuned Constant Envelope-delay Band-pass Amplifiers

The normalized envelope-delay function (of frequency),

derived from the mathematical analysis of a stagger-tuned band-pass amplifier, was expressed as a summation of the envelope-delay functions of the individual interstage coupling networks. The problem was to find the condition such that the envelope-delay characteristic of the amplifier had least variation over the pass-band. As no rigorous mathematical treatment was available, an approximation method was derived based on the following assumptions.

(1) that the envelope-delay function is symmetrical with respect to the mid-band frequency.

(2) that the envelope-delay function has least variation if its maximum points are on the same level.

(3) that the maximum points occur at frequencies very close to the resonant frequencies of the individual interstage networks.

(4) that the resonant frequencies of the interstage networks are placed at equal intervals.

Equations were derived to give the figure of merit, Q, of each interstage network, as a function of the band-width, the number of stages, and the Q of the center stage. Values of circuit parameters were provided by another set of equations. Normalized response characteristics for amplifiers of three to six stages were prepared to be used as a reference for the design of the constant envelope-delay band-pass amplifiers.

Experimental

The performance of the constant amplitude amplifier and the constant envelope-delay amplifier were investigated in the laboratory with two carefully built five-stage stagger-tuned band-pass amplifiers. Gain measurements were made to ensure a close agreement between the theoretical and experimental values of the response characteristics of both amplifiers. The unit voltage responses of the two types of amplifiers were studied with a fast cathode-ray oscilloscope. As predicted, the constant envelope-delay amplifier gave a sym-

metrical transition with very little overshoot. While the constant amplitude amplifier gave a slightly shorter rise time, its advantage was offset by the rather large overshoot, which was undesirable in a television system.

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VITA

Arthur Wu-nien Lo was born in Shanghai, China, on May 21, 1916. He received the B.S. degree in physics from Yenching University, China, in 1938. From 1938 to 1942 he was an assistant in physics at the West China Union University; and from 1942 to 1944, a lecturer in physics at Yenching University. After he came to the United States in 1945 he took graduate work and served as a half-time teaching assistant at Oberlin College, and received the M.A. degree in physics in 1946. After this, he came to the University of Illinois for graduate work in electrical engineering as a graduate fellow, and was appointed a half-time research associate in 1948.

He is a member of the Sigma Xi, Phi Kappa Phi, Pi Mu Epsilon, and Eta Kappa Nu honorary societies.

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